contributed by himself to the Loan Collection, representing the results of his admirably conducted series of researches in connection with this particular one of those metals designated by the chemist as "rare." The President, in thanking Prof. Roscoe, remarked, in reference to the value of scientific research, that it could not be too widely known that all the greatest results to which it had conduced had been obtained primarily by devotion to purely abstract science—practical applications having unexpectedly followed upon discovery. Prof. Guthrie, F.R.S., then gave an account of his researches on "Cryohydrates and Water of Crystallisation," a subject on which he has been working for the last three years. Prof. Williamson, F.R.S., gave an address on the "Manufacture of Steel," limiting his attention chiefly to the modes devised for the obviation and repression of the escape of carbonic oxide gas from molten steel during the casting and cooling process, after leaving the Bessemer or Siemens-Martin furnace. Mr. W. C. Roberts, F.R.S., subsequently read a paper, on the "Apparatus used by the late Prof. Graham in his Researches." The principal interest attaching to these pieces of apparatus was the simplicity of the means by which the late Master of the Mint established such important discoveries as the law of the diffusion of gases, the principle of the endosmotic action of fluids, and the consequent division of chemical substances into crystalloids and colloids. Mr. W. N. Hartley read a paper on the existence of "Liquid Carbonic Acid in the Cavities of Crystals," Dr. Gladstone, F.R.S., following with a short address on the electrolysis of organic compounds with the copper zinc couple. Dr. Frankland, in closing the Chemical Conference, congratulated the audience upon the success which had attended the proceedings throughout the two meetings.

Yesterday the Section of Physics met for the third time, when the following papers were to be read :—

Prof. J. Clerk Maxwell, "On the Equilibrium of Heterogeneous Bodies ;" Prof. Andrews, "On the Liquid and Gaseous States of Bodies ;" M. Sarasin-Diodati, "On M. de la Rive's Experiments in Statical Electricity ;" M. Lemström, "Sur l'Aurore Boréale ;" Baron F. de Wrangell, "On a New Form of Voltameter ;" Il Commendatore Professore Blaserna, "Sur l'état Variable des Courants Electriques ;" Mr. Warren de la Rue, "On Astronomical Photography ;" Mr. Ranyard, "On the Instruments lent by the Royal Astronomical Society ;" Mr. Brooke, "On Magnetic Registration, and on the Corrections of the Magnetometers ;" Prof. Carey Foster, "On Electrical Measurements ;" Herr Prof. Dr. Rijke, "On the Historical Instruments from Leyden and Cassel ;" the Rev. R. Main, "On a Telescope of Sir W. Herschel's."

The third meeting of the Mechanical Section is held to-day.

The first meeting in the Section of Biology will take place to-morrow, when the following papers will be read :—Dr. J. B. Sanderson, the President, "On Methods of Physiological Measurement and Registration ;" Prof. Marey "On various Instruments for Investigating and Registering Vital Movements ;" Dr. Hooker "On the Plan of the New Laboratory for Investigations relating to the Physiology of Plants at Kew ;" Prof. Dyer "On various Apparatus for Investigating and Registering the Growth of Plants contributed by the Physiological Laboratory of Bremen ;" Dr. P. L. Sclater "On Drawings contributed by the Zoological Society ;" Dr. Brunton "On a new Myographic Apparatus ;" Dr. Klein "On Recording Apparatus exhibited by the Physiological Institute of the University of Prague ;" M. E. A. Schafer "On recent Improvements in Recording Apparatus."

The Science and Art Department are organising a series of popular lectures to be given on the evenings of the free days. Demonstrations of the objects in the galleries are also now given by the exhibitors or other competent persons at frequent intervals during the day.

SECTION—CHEMISTRY.

Opening Address by the President, Dr. Frankland, F.R.S.

THE Conference which I have been requested to open to-day has for its object the discussion of the merits and defects of the various forms of chemical apparatus exhibited in these buildings ; and the criticism of the original investigations which are here illustrated, partly by the instruments used in them, and partly by the chemical compounds, to the discovery of which they have led.

Various objects interesting to chemists have been displayed in former international exhibitions, but it may be safely asserted that such a collection as this, which has been brought together in these buildings, has never before been seen ; neither has there before been the opportunity for discussion and criticism, by men eminent in science from all parts of Europe, which is now afforded.

Such a collection of apparatus and products, gathered from all parts of Europe is useful in disclosing, to chemical investigators and others, the best sources whence to procure apparatus ; it is interesting historically and as showing the improvements in chemical apparatus during the present century ; and it is instructive in the comparisons it affords of the various forms of instruments used for the same purpose in different countries, and by different experimenters.

The entire novelty of such a collection as that belonging to this section has rendered the attainment of the object sought for, on the present occasion, exceedingly difficult. The workers in science have hitherto had no inducement to preserve the *instruments* with which they experimented. When an investigation was finished the apparatus employed was dismantled and converted to other uses. Still less inducement has there been to preserve the *chemical compounds* resulting from research, although their creation required, in many cases, a great expenditure of time and labour. The chief object of preparing such compounds has hitherto been, in most cases, merely to ascertain their existence, to show their molecular relations to previously known bodies, and to ascertain a few of their leading properties such as colour, specific gravity, vapour density, melting point, boiling point, and chemical composition. They have been weighed and measured and then dismissed out of existence. And thus the present collection of chemical preparations is but the merest skeleton of a complete exposition of all known chemical compounds.

It is, indeed, remarkable, that whilst *natural* chemical compounds are exhibited in almost endlessly multiplied specimens in the mineralogical collections of our national museums, the *artificial* compounds which have resulted from research, or have been the foundation of important theories and generalisations, have nowhere been honoured by admission into national collections. The neglect, not to say contempt, with which these productions of the laboratory have been treated, cannot be justified on the ground of their want of national utility. It is true that from an exclusively commercial point of view, no one of them can lay claim to the importance of coal, iron, silver, and gold. Still, many of them, such as the paraffins, the coal-tar colours, and many of the compounds of sulphur, potassium, sodium, and ammonium, have contributed, in an important degree, to the wealth and prosperity of this and other states. Had these artificial compounds remained undiscovered, how different would now have been the condition of the industries of bleaching, dyeing, calico-printing, glass-making, and the manufactures connected with the production of artificial light. Many of these artificial compounds have become of the most essential importance to the physician, the artist, the telegraphist, the engineer, and the manufacturer, and it cannot be doubted that many more would soon come into active service for such purposes if they were better known.

But not alone on the ground of utility and incentive to the further useful discovery of technical applications would I plead for the establishment of national museums of chemical preparations; such collections would be of the highest interest both to the student and the investigator. They would call vividly before the mind the results of labours which can only otherwise become known by a tedious search through the transactions of learned societies. An intelligent study of a properly arranged collection of artificial chemical compounds would show the progressive triumph of mind over matter—not over masses moved by mechanical agencies—for monuments of this the engineer and the architect need only bid the inquirer, in the language of Wren's tablet, to "look around him"—but over the ultimate atoms which, in these compounds, are compelled to submit themselves to the will of man, and to form new structures, seen only, in most cases, by the discoverer himself, and the qualities and uses of which are but very imperfectly ascertained. Nine-tenths of these compounds are no better known than islands which have been seen only from the deck of a ship and whose position has been accurately marked upon a chart. But a collection of them, if properly kept up, would represent the actual condition of our knowledge of chemical facts, and, if properly arranged, would suggest to the observant student the direction of future investigation.

I know of no other incentive to research which would be more likely to call original inquirers into existence. The student wishing to commence a chemical investigation is always confronted at the outset by the difficulty of finding the boundary line between the known and the unknown, and this difficulty must obviously increase from year to year owing to the continued expansion of the circle of knowledge. It has led to a suggestion emanating from the British Association, that chemists who are intimately acquainted with particular departments of their science should suggest subjects of research for the benefit of students. Much may be said no doubt in favour of such a scheme; but it appears to me that the development of original talent in the young investigator would be more surely promoted by giving him the means of selecting for himself a subject for experimental inquiry, rather than by inducing him to follow the less invigorating plan of working out the suggestions of others. I venture, therefore, thus prominently to call attention to the non-existence, in any country, of a museum of artificial compounds, and to the great value, both economical, scientific, and educational, which such a museum would possess. I feel convinced that if such museums were established in the capitals of Europe, chemical investigators throughout the world would gladly contribute their new products to them, and thus keep them abreast of the discoveries of chemical science.

Amongst the groups of objects in the Chemical Section, not the least interesting is that which consists of *Apparatus and Contrivances employed in the Generation and Application of Heat.* The great advances which have been made in the modes of producing and applying heat for chemical purposes are strikingly conspicuous. The cumbrous furnaces of the earlier operators, constructed in fireproof vaults, have gradually been replaced by simple and elegant contrivances, which would scarcely look out of place upon a drawing-room table. The time is still fresh in the recollection of many of us, when the fusion of a silicate for quantitative analysis, or the heating to redness of oxide of copper for the combustion of an organic compound, required in each case the expenditure of much time and trouble in the lighting of a coke or charcoal furnace. Now these operations are performed in small gas furnaces with or without air blast. Conspicuous amongst these inventions are the gas-burners of Bunsen and Hofmann, the oxy-coal gas furnaces of Deville, the blast gas furnaces of Griffin, and the hot blast gas furnaces of Fletcher. Of these fundamental inventions many ingenious modifications for special purposes have been devised, amongst which I may mention the valuable contrivances of Finkener, Mitscherlich, Wallace and Müncke. The blast gas-burners of Hofmann and Bunsen, the blast gas-furnaces of Deville, Griffin, and Bunsen, and the furnaces for organic analysis by Hofmann, Bunsen, Finkener, Mitscherlich, and Müncke, are amongst the exhibits illustrating the application of heat in chemical operations.

These burners and furnaces command a range of temperature from the gentlest ignition up to the most intense heat procurable by chemical means; but the temperature produced by such combinations as those of oxygen and hydrogen, or oxygen and carbon, enormously high though it be, now no longer suffices, and recourse must be had to the still more intense heat of the electric discharge. The electric current and the stream of sparks are now not unfrequently called into requisition by the chemist, and from this point of view the electric lamp and the apparatus of Hofmann and others for the decomposition of gases by the spark-stream must be classed with chemical furnaces.

To apparatus for the application of heat belong the various forms of water, steam, and air baths, or drying closets. Convenient contrivances of this class invented by Bunsen, Mitscherlich, Habermann, and Müncke, are exhibited by Messrs. Warmbrunn, Quilitz and Co., Mr. Johann Lentz, and Mr. Julius Schober all of Berlin, and by Mr. C. Desaga of Heidelberg.

In the application of gas to chemical purposes, regulators of pressure and temperature are often of the utmost importance, in order that operations requiring the prolonged and regular action of heat may not require the constant attention of the operator. The ingenious and effective contrivances of Bunsen and Kramer, for this purpose are exhibited.

Closely connected again with appliances for raising temperature are those intended for its reduction—the refrigerators or condensers.—The Liebig's condenser is still the refrigerator almost exclusively used, but few pieces of apparatus have been so much modified and refined, as will be seen on comparing the original design with the present construction—the final light and convenient form having been given to it by my late friend Mr. B. F. Duppa. Most manufacturers of chemical apparatus exhibit various forms of this condenser.

Sprengel Pumps.—Of the comparatively recent appliances for facilitating chemical work, few can lay claim to higher merit than the invention of Dr. Hermann Sprengel, in the year 1865, for the production of vacua by the fall of liquids in tubes; and yet this invention remained for many years dormant, until the late Master of the Mint applied the mercurial pump to the extraction and collection of occluded gases, and Bunsen the water-pump to hastening the filtration of liquids. Without the mercurial pump the elements of the organic matter in potable waters could not be determined, and the highly interesting results which this pump has quite recently achieved in the hands of Mr. Crookes, come home to every one who has seen the various forms of the radiometer.

Bunsen's application of the water-pump to filtration has done much to shorten one of the most tedious and troublesome operations of gravimetrical analysis.

Dr. Sprengel's invention has, moreover, nearly abolished the use of the air-pump in chemical laboratories, and I need not therefore, perhaps, bring under the special notice of this section the various improvements in air-pumps which are illustrated by the exhibits in the Physical Section.

Models, diagrams, apparatus and chemicals used in the teaching of chemistry, include numerous exhibits of great interest. It is to be regretted, however, that models and plans of chemical laboratories are not more numerously represented. The important improvements which have been introduced of late years, and the numerous laboratories of truly palatial proportions which have been built,

in almost every case at the cost of the State, would have rendered a complete exposition of their plans and fittings most instructive and interesting. Dr. de Loos, has, however, sent us a model of the chemical laboratory in the secondary Town School of Leyden. And we have from Mr. Waterhouse plans of the Owens College laboratories in Manchester. The latter were devised after the professor of Chemistry and the architect had visited all the great laboratories of Europe, and for compactness, economy of space, appropriateness of fittings, and ventilation, they are unsurpassed.

In illustration of the permanent fittings of laboratories, we have from the Chemical Institute of the University of Strassburg a diagram showing elevation, section, and plan of a "digestorium," or iron closet, for use in dangerous operations in which explosions are liable to occur. This is a contrivance which ought never to be absent from a laboratory in which research is carried on.

Prof. Roscoe exhibits a beautiful and effective series of diagrams and models illustrating the processes carried on in alkali works, and Mr. Henry Deacon a sectional model of his ingenious apparatus for exposing porous materials and currents of gases to mutual action.

Dr. de Loos, of Leyden, has sent drawings of gas works used for teaching technical chemistry in secondary schools.

We are indebted to Mr. Spence, of Manchester, for a series of specimens illustrating his process for the manufacture of ammonia-alum. To Messrs. Roberts, Dale and Co. for specimens illustrating the manufacture of oxalic acid. To Messrs. Calvert and Co. for similar illustrations of the manufacture of carbolic, cressylic and picric acids.

Messrs. Hargreaves and Robinson exhibit plans and specimens in connection with their new process of manufacturing sulphate of soda directly from sulphurous acid, steam, air, and salt; whereby the intermediate production of sulphuric acid is avoided. A chemical factory is generally conspicuous in the landscape by a series of huge and ugly leaden vitriol-chambers. Should the new process prove as successful as the inventors anticipate, these leaden chambers will almost entirely disappear, and the aspect of chemical factories will undergo a more profound modification than any which has occurred during the last half century.

The splendid platinum apparatus of Messrs. Johnson and Matthey for the concentration of sulphuric acid, will also contribute much to compactness in chemical works, by the abolition of cumbrous leaden pans and long ranges of glass retorts.

Not only is the sense of sight thus likely to be relieved, but that of smell, which, in the case of chemical works, is perhaps of even more importance, is also gradually being subjected to less offence by the adoption of Mond's process for the recovery of sulphur from soda-waste. The vast mounds of this material which surround alkali works, not only pollute the air with sulphuretted hydrogen; but also the neighbouring streams, with an offensive drainage which is very destructive to fish life. Herr Mond has succeeded in profitably extracting the sulphur—the offending constituent of the waste—and Messrs. John Hutchinson & Co. of Widness, exhibit specimens illustrating this important process.

Dr. Van Rijn, of Venlo, Netherlands, exhibits fine crystals of potash and chrome alums. One of the Octohedrons of potash alum weighs no less than 11 lbs.

Messrs. W. J. Norris and Brother of Calder Chemical Works have sent specimens useful in teaching the technology of lichen colours, sulphate of alumina, and bichromate of potash.

Messrs. Brooke, Simpson, and Spiller contribute a fine series of specimens illustrating the technology of coal-tar colours.

Lastly, several magnificent series of specimens have been sent over by members of the German Chemical Society.

They comprise, firstly, some items of much historical interest. Thus, we have from Prof. Wöhler the first specimens of boron and aluminium ever prepared. And, from the same chemist, another historical specimen which, it is no exaggeration to say, is the most interesting now in existence, for, after the discovery of oxygen, it marks the greatest epoch in chemical science. I allude to this specimen of the first organic compound prepared synthetically from its elements by Wöhler, without the aid of vitality. If the work of the army of chemists who have successfully attacked the problems of organic chemistry during the last quarter of a century were to be described in one word, that word would be SYNTHESIS. In this specimen of urea we have then the germ of that vast amount of synthetical work which has done so much to dispel the superstition of vital force and to win for chemistry the position of an exact science. In the absence of a specimen of the first oxygen from Priestley's laboratory in 1774, it seems to me that this specimen of the first synthesised urea made in 1828 is, historically, the most interesting chemical the world has to show.

Secondly, we have a beautiful collection of all the compounds discovered by Liebig, but I need not dwell upon them, as they have been so recently described by their exhibitor, Prof. Hofmann, in his Faraday lecture delivered to the Fellows of the English Chemical Society.

And thirdly, there are several interesting series of specimens illustrating the researches of Biedermann, Weltzien, Michaelis, Hübner, Hofmann, Lieberman, Oppenheim, Pinner, Wichelhaus, Tiemann, and others.

We come now to a review of that sub-division of the Chemical Section which illustrates original research, viz., chemical compounds discovered in certain specific investigations, and apparatus used in the prosecution of research. Whilst the sub-division which I have been describing illustrates for the most part the training of the young chemist in habits of observation and in the use of apparatus and processes, the one we are now considering aims at representing, so far as it can be objectively represented, the highest outcome of this training—the additions to our knowledge acquired through the accurate methods of observation and experiment which it is the function of the chemical instructor to teach. I have already remarked on the interest and importance of exhibits of this class, and it is to be regretted that out of so many chemical investigators so few have exhibited. It is characteristic of the direction long taken by chemical research, that of about 25 exhibitors only two have contributed mineral as distinguished from organic products.

Prof. Roscoe exhibits sixty-five compounds of vanadium discovered and investigated by himself. This classical research stands out as a model of thoroughness, and not only clearly discloses the habits of a comparatively rare metal, but brings to light some new and interesting facts in connection with the theory of atomicity. As Prof. Roscoe has consented to deliver an address on these compounds, we shall have an opportunity of discussing the peculiarities and anomalies which have presented themselves in the course of this investigation.

The water of crystallisation of salts has been the subject of some controversy amongst chemists of late. It is generally considered to be present in atomic proportions, however complex these may sometimes be, and most chemists are inclined to regard the bond of union between this water and the salt proper in the light of a *molecular*, as distinguished from an *atomic*, attraction. Mr. Walcott Gibbs, however, has recently endeavoured to show that the union is strictly atomic, and subject to the ordinary laws of atomicity. The subject has attracted the attention of Prof. Guthrie, who has attacked it from a new side, and obtained results which throw much light on this question. He has promised to give us an address on the subject at the next Chemical Conference. Prof. Guthrie also exhibits—

Nitroxide of Amylen.—Discovered by the exhibitor. Of historical interest as being the first instance in which nitroxyl NO_2 was shown to behave as a halogen in uniting directly with an olefine to form a body homologous with "Dutch liquid." The composition of the body is $C_5H_{10}(NO_2)_2$.

Sulphide of Œnanthyl.—Discovered by the exhibitor, and of historical interest as being the first instance in which a term of a higher alcohol series was made from terms of lower alcohols. It is formed by the action of zinc ethyl on sulpho-chloride of amylen.

And Nitrate of Amyl.—Discovered by M. Balard. Its therapeutic action was discovered, and its introduction into the pharmacopœia recommended, by the exhibitor; and it is now coming into use in tetanic and other nervous affections.

A series of twenty-three specimens of hydrocarbons derived from Pennsylvanian petroleum is exhibited by Prof. Schorlemmer. They form a striking record of the skill with which a most laborious and difficult investigation has been conducted.

Very interesting and important are the ethyl compounds derived from the isolated radical methyl exhibited by Mr. W. H. Darling. The results of some experiments made by myself seemed to indicate that the products of the action of chlorine upon methyl were not ethyl compounds; but the experiments of Schorlemmer and Darling conducted with much larger quantities of material, show that my conclusion was erroneous. Mr. Darling exhibits ethylic chloride, ethylic alcohol, ethylidenic chloride and sodic acetate, all made from electrolytic methyl.

Mr. Perkin has sent a large collection of specimens illustrating his researches on mauveine, artificial alizarin, artificial coumarin, glyoxylic acid, and other subjects. His investigation of glyoxylic acid seems to have at last put an end to the controversy as to the possibility of two semimolecules of hydroxyl being united with one and the same atom of carbon. I will not, however, anticipate Mr. Perkin, who will, I trust, personally give us an account of his researches.

Amongst the other exhibits in this department are numerous and important contributions from the laboratories of St. Petersburg, Louvain and Edinburgh. For several years past chemical research has been actively carried on in Russia.

The apparatus used in Research exhibited in the Chemical Section has suffered much from the depredations of the physicists, for although chemistry is essentially founded upon measurements of weight and volume, the instruments used for such determinations have been swept almost *en masse* into the section of measurement; nevertheless, the chemical section contains several objects of unusual interest. The apparatus with which chemists, both ancient and modern, prosecuted their researches was generally of a simple description and often dismantled as soon as the necessary operations were completed, consequently it was far less likely to be preserved than the more expensive and elaborate contrivances of the physicist. Here, however, is Black's balance presented to the Science and Art Museum of Edinburgh, by the Right Hon. Lyon Playfair. Upon this balance Dr. Black ascertained in 1757, the loss of weight suffered by carbonate of magnesia and limestone when exposed to heat. Hales previously used a balance for this purpose, but the instrument before us was certainly one of the first employed for quantitative chemistry. The balances used by Cavendish, Davy, Young, and Dalton are here, and each one of them has its own historical interest for the chemist The balance of Cavendish is probably the instrument with which in 1783 or 1784 he first ascertained that a globe filled with a mixture of oxygen and hydrogen gases underwent no alteration in weight when the mixture was exploded.

From gravimetric instruments we are naturally led to volumetric apparatus used in quantitative chemistry, and I will now, in conclusion, briefly direct the attention of the conference to apparatus used in the analysis of gases, in the hope that a discussion of the merits and defects of the numerous instruments now before me may have the effect of directing a larger share of attention to eudiometric chemistry than has hitherto been accorded to it. This branch of chemical analysis originated in the attempts of Fontana, Landriani, Scheele, Priestley, Cavendish, Gay Lussac, Dalton, and others, to determine the volume of oxygen in samples of atmospheric air taken from various localities. In these primitive instruments air was exposed to the action of some substance either solid, liquid, or gaseous, which combined with the oxygen and left the nitrogen unacted upon. The chief substances used were phosphorus, potassic sulphide, nitric oxide, a solution of nitric oxide in ferrous sulphate, and a mixture of sulphur and iron filings. Many of the instruments were of simple or even rude construction, and little calculated to inspire confidence in the results. Nevertheless, the accuracy of a determination often depends much more upon the skill of the operator than upon the construction of the instrument used; and thus Cavendish, with nitric oxide as his reagent and water as the confining liquid, made many hundred analyses of air, collected in various localities, in 1781, and found the percentage of oxygen to be invariably 20·83, a number nearly identical with those obtained by Bunsen and Regnault with much more perfect means. But the average chemist of that day obtained the most discordant results with the same apparatus and materials, and would doubtless also do so at the present day. By improved apparatus and methods the work of the average chemist is made to equal, or nearly so, that of the most skilful.

Volta introduced a new reagent—hydrogen—for the determination of oxygen, and he was the first to employ the electric spark in eudiometry. The use of mercury instead of water for confining the gases eliminated, the source of fallacy caused by transfusion through the latter liquid, and lastly, Bunsen, in the year 1839, brought Volta's eudiometer to its highest degree of perfection.

The President then proceeded to describe and criticise the various forms of apparatus for the analysis of gaseous mixtures, and concluded as follows:—

Such are the modern developments of the eudiometer now at the disposal of chemists. For rapidity of working and delicacy of measurement they leave nothing to be desired; indeed, as regards delicacy, it may be doubted whether amongst all the instruments for measurement in this exhibition, there is one which can, like some of these eudiometers, give a distinct value in weight or volume to the one-fourteen-millionth part of a gramme of matter. Their drawback is their fragility, and any modifications to diminish this would doubtless be welcomed by chemists, since, chiefly for these reasons, eudiometry is still very rarely practised in chemical laboratories.

THE PRESS ON THE LOAN COLLECTION

In continuation of our article in last week's number we proceed to give a few more selections from the principal organs of public opinion, indicative of the light in which they regard the scientific collection which has been brought together at South Kensington. Last week we confined ourselves mainly to the daily press; this week we are able to cull the opinions of the principal weekly papers. Public opinion as thus expressed, it will be seen, all but unanimously approves of the collection as creditable to its organizers and to the country at large, as beneficial to the progress of science, and as calculated to have an important educative influence on the British public. We think the collection of public opinion as thus expressed will serve a good purpose. It will show to those men of science who have been more or less connected with the